Notes on Economic Warfare

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In this paper I shall adopt the Intriligator-Brito (1975, 1983) model of bipolar international conflict and show: (1) how an open-ended arms race is a form of economic warfare that may lead to military warfare; and (2) how a policy of deterrence may escalate into an open-ended arms race if the two nations have different factor endowments. These conclusions are drawn from ordinary economic diagrams similar to those in use in first courses in international trade. Some policy conclusions are drawn for the prevention of war in present circumstances that differ from those of Intriligator-Brito which may have been appropriate to earlier years of more limited military programs. In this my emphasis will lead away from their strictly nuclear missile conception of the arms race, which *does* tend to emphasize deterrence in the use of *these specific weapons*, and toward the total production of military power through arms acquisition which stresses the crowding out of economic growth in opposing countries. This view of the arms race shows the inherent *instability* of open ended deterrence strategies.*

I.

A brief summary of the Intriligator and Brito model is in order. They first study a missile war between two countries A and B [Intriligator, 1967, 1975; Intriligator & Brito, 1983]. Missiles are the only weapon which the countries hold in amounts M_A and M_B respectively. These missiles may be fired at rates α, β up to a maximum $\bar{\alpha}$, $\bar{\beta}$. They may be targeted in proportions α', β' against enemy missiles, called *counter-*

force targeting, or against populations $(1-\alpha')$, $(1-\beta')$ *countervalue targeting*. The effectiveness of these missiles in counterforce application measured in missiles destroyed for each missile launched is f_A and f_B, respectively. Countervalue effectiveness in killing people per missile is V_A and V_B. Designating casualties on each side by C_A and C_B, Intriligator and Brito are able to write the following system of first order differential equations for the missile stocks depleted through being used up or destroyed by enemy counterforce missiles. The casualty count as the missile war proceeds for its few moments of duration is as follows:

$$\dot{M}_A = -\alpha M_A - \beta\beta' M_B f_B$$

$$\dot{M} = -\beta M_B - \alpha\alpha' M_A f_A$$

$$\dot{C}_A = (1-\beta')\beta M_B V_B$$

$$\dot{C}_B = (1-\alpha')\alpha M_A V_A$$

With initial conditions $M_A(0)$, $M_B(0) > 0$, $C_A(0) = C_B(0) = 0$. These may be solved for C_A and C_B in terms of M_A and M_B, the structural parameters of the system and duration of missile firing.[1]

They then can set *boundaries* on the accumulation of missiles in an arms race $\{M_A(t), M_B(t)\}$, defining regions of deterrence or initiation of hostilities. A *deters* B if

$$M_A \geqq f_B M_B(1 - e^{-\bar{\beta}\Theta_B}) + \frac{\bar{C}_B}{V_A(1 - e^{-\bar{\alpha}\Psi_A})}$$

We can understand this relationship better by allowing the time intervals Θ, Ψ, or the maximum rates of fire α, β to be "large" so that the exponential terms are close to zero. Then the condition for deterrence is

$$M_A \geqq f_B M_B + \frac{\bar{C}_B}{V_A}$$

which can be translated as: The number of missiles belonging to A is greater than or equal to B's capacity to destroy A's missiles, and A is left with enough missiles to inflict unacceptable casualties on B.

Peace is maintained when A deters B and B deters A. We may say this is when the arms race remains in the zone of mutual deterrence, ξ, $\{M_A(t), M_B(t)\} \varepsilon \xi$.

In contrast, *A attacks B* if

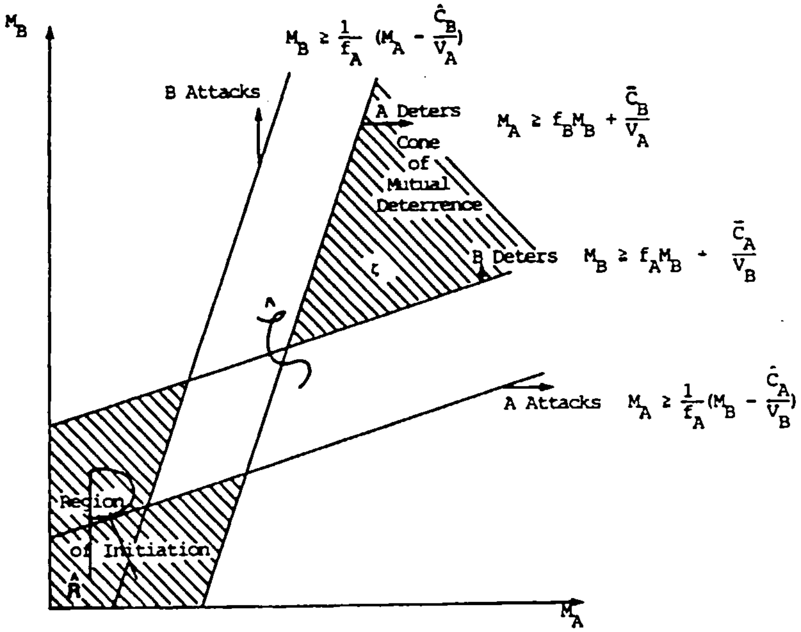
$$M_A \geq \frac{M_B}{f_A(1 - e^{-\bar{\alpha}\Theta_A})} - \frac{\hat{C}_A}{f_A(1 - e^{-\bar{\alpha}\Theta_A})\ V_B(1 - e^{-\bar{\beta}\Psi_B})}$$

Letting Θ, Ψ be large,

$$M_A \geqq f_A(M_B - \frac{\hat{C}_A}{V_B}) \text{ or equivalently } M_A f_A + \frac{\hat{C}_A}{V_B} \geqq M_B.$$

Translated, the last inequality says: A attacks B if the number of A's missiles converted into its ability to destroy B missiles ($M_A f_A$), plus its willingness to absorb casualties by B's remaining missiles at least equals the number of missiles that B has available. (See Figure 1).

Figure 1
Deterring and Initiating Regions
in the Weapons Plane


M_B
$M_B \geq \frac{1}{f_A} (M_A - \frac{\hat{C}_B}{V_A})$
B Attacks
A Deters
$M_A \geq f_B M_B + \frac{\bar{C}_B}{V_A}$
Cone of Mutual Deterrence
ζ
B Deters
$M_B \geq f_A M_B + \frac{\bar{C}_A}{V_B}$
$\hat{\zeta}$
A Attacks
$M_A \geq \frac{1}{f_A}(M_B - \frac{\hat{C}_A}{V_B})$
Region of Initiation
$\hat{R}$
M_A

Ongoing wars are inevitable in some "region of initiation", R, where each country can attack the other at an acceptable level of casualties, yet cannot deter the victim from striking back. Clearly this may include a region $\hat{R}$ where both parties initiate conflict, $R \supset \hat{R}$.

These boundaries are illustrated in Intriligator and Brito's basic diagram (Figure 1). In accord with these boundaries we may define $\hat{\zeta} \supset \zeta$. But if the arms race departs from ζ, war is found to occur because A will attack B, or B will attack A, or both will attack. The region R is one in which one party will attack, and the other will strike back. The region $\hat{R} \cap R$ is one in which both will strike, and both will strike back. Intriligator and Brito argue that roughly equal *low* levels of arms are in R while rough parity of higher levels lies within ζ; their conclusion follows that the arms race is an instrument for relative peace as witnessed by the post World War II world of the absence of direct nuclear conflict between the US and USSR.

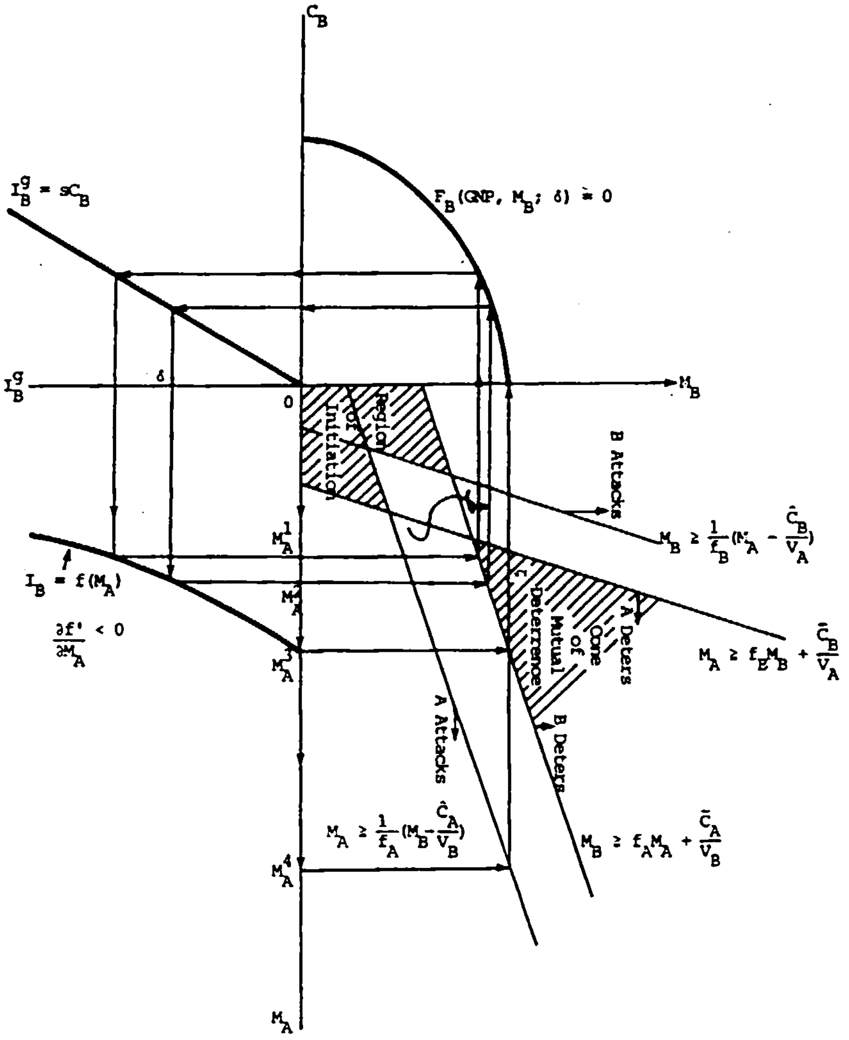
II.

In their early papers, Intriligator and Brito take the sets ζ and $\hat{\zeta}$ as closed, but not bounded from above.[2] This is not an implausible formulation if one is concerned with the actual progress of a nuclear war measured in minutes, so that the issue appears to be the size, efficacy and targeting of such weapons rather than their production. Nevertheless as the arms race expands, even within ζ, arms budgets engross larger portions of GNP and exceed amounts that might be justified as fiscal stimulation. Then the significance of the arms race changes from one of the threats of potential military action to a form of economic warfare itself. Each nation must maintain a deterrent to the arms buildup of the other, and necessarily this military allocation is at the expense of the civilian sector. That is to say, nation A may, by means of its own military expenditure, "crowd out" the civilian sector of its antagonist. (Joint Hearings, 1983, p. 489)

The process of economic warfare can be represented by the four-quadrant diagram (Figure 2) in which the Intriligator-Brito deterrence model appears in the lower-right quadrant and serves to keep the armament programs of Country A and Country B roughly in step with one another. The upper right quadrant shows the production possibility frontier for country B in which M_B is generalized from missiles in Intriligator and Brito to the production of military power;[3] C_B is the civilian sector, GNP minus military expenditures. The upper left quadrant is a simple savings (equal to investment) function relating gross investment to the civilian sector of GNP, $I^g_B = sC_B$ where s is the average propensity to save taken as given by the national authorities. δ indicates the level of depreciation of the capital stock so that net investment, $I_B = I^g_B - \delta$. Consequently, the lower left quadrant is a reduced form equation which maps the military expenditure of A into the gross investment of B. Crowding out is embodied in its negative slope.

Suppose that the interval $[O, M^4_A]$ lies within the production possibility frontier of A (not shown) at some level it is able to tolerate. Then we can visualize four levels of intensity of economic warfare of A against B.

Figure 2
Levels of Economic Warfare


C_B
$I_B^g = sC_B$
$F_B(GNP, M_B; \delta) = 0$
I_B^g
δ
0
M_B
Region of Initiation
B Attacks
$M_B \geq \frac{1}{f_B}(M_A - \frac{\bar{C}_B}{V_A})$
M_A^1
$I_B = f(M_A)$
M_A^2
$\frac{\partial f'}{\partial M_A} < 0$
Cone of Mutual Deterrence
A Deters
$M_A \geq f_B M_B + \frac{\bar{C}_B}{V_A}$
M_A^3
A Attacks
B Deters
$M_A \geq \frac{1}{f_A}(M_B - \frac{\hat{C}_A}{V_B})$
$M_B \geq f_A M_A + \frac{\bar{C}_A}{V_B}$
M_A^4
M_A

(1) *Crowding Out*: For any M_A such as $M_A^2 > M_A^1 > 0$ a *cost is imposed* on the civilian sector of the economy B. For any M_A^1, country B must either submit to A or generate enough military strength to deter A. This level of M_B then determines the size of the civilian sector though the production possibility frontier and, consequently, the amount of gross investment in human as well as physical capital that takes place. Clearly each increase in M_A reduces I_B^g, and, of course, reduces consumption by B as well.

(2) *Erosion of Capital:* For $M_A^3 > M_A > M_A^2$, the level of gross investment in B lies below the replacement level, so that net investment is negative. Consequently, the economic warfare of country A successfully destroys part of the capital stock of B. (Hearings, 1983, pp. 80-81).

(3) *"Negotiation From Strength":* For $M_A^4 > M_A > M_A^3$, A has made it impossible for B to deter a military attack. While it is not clear that A will attack B in a "first strike," B no longer has enough military strength to survive a first strike by A and still inflict unacceptable casualties on A, even if B's total GNP were devoted to military purposes ($M_B < f_A M_A + \bar{C}_A/V_B$)

(4) *Initiation of Military War:* For $M_A \geq M_A^4$, A has been able to achieve a military buildup sufficient to neutralize the force that B can produce (even if all its GNP went to military purposes) and still endure only acceptable casualties ($M_B \leq f_A M_A + \bar{C}_A/V_B$).[4]

It is clear that the addition of an upper bound through the recognition of economic realities makes arms races much more dangerous than Intriligator and Brito have suggested. In fact arms races are acts of economic war that, if allowed to continue, lead to military war. The fact that not all past arms races have led to war (Lambelet, 1975, pp. 123-24) is not particularly revealing since we are discussing a special kind of total war which pits economic systems against one another by both military and economic means combined. The danger is that the side that is *losing* the economic war has every incentive to initiate military action before it reaches a point like M_A^3. (Reischauer, 1977, pp. 101-02; Reischauer and Craig, 1978, pp. 262-63).

Now if we extend our analysis to view this question in its dynamic aspect, we can see that since it is the comparative military power of the antagonists that is at issue in remaining inside ζ, a shift in the production possibility frontier of one country with respect to another can escalate the level of economic warfare of types (1) or (2) into types (3) or (4) with the same level of military power production. We leave it as an exercise of the reader to alter Figure 2 to make this point. In the extreme, country A might crowd out the gross investment of B to less than the replacement of capital level δ. If A maintains this posture for enough periods, the production possibilities of B shift inward and consequently progressively escalate the level of hostilities to the point of military warfare. But the danger of war exists even before this extreme. Even if $I_g^B > \delta^B$, the more rapid growth of production possibilities of A compared to B ($I_g^A - \delta^A > I_g^B > \delta^B$) may bring about the same exacerbation of conflict. After all the conduct of war is aimed at the destruction of the military power of the enemy and the imposition of unbearable cost on him. Clearly this can be done by an arms race as well as by military war.

The nature of the pressures at work in the Soviet Union as a result of the arms race were discussed in the Joint Economic Committee by

General Schuyler Bissell, Deputy Director of the Defense Intelligence Agency. (Joint Hearings, 1983). The same committee has studied the impact on the U.S. (Defense Buildup, 1982). Evidently the US and USSR are playing a game of economic warfare in which the rate of military expenditures and deterrence has the effect of linking the capital allocation of the two countries almost as if there were a market nexus between them. Of course the linkage has its quirks, such as the demands of the military in both countries for enlarged budgets for purely bureaucratic reasons, regardless of the impact on the economy. Moreover, the military serves as a political instrument for the extension of national power in third countries where swirls of subconflicts that take place are only partially a proxy for the US-USSR bipolar antagonism.

The capital market linkage between the US-USSR causes the bipolar conflict to overflow into international capital and resource markets. The arms buildup in the US takes place under a regime of flexible exchange rates, free international capital flows, restrictive monetary policy, and expansive military related fiscal policy. In addition to crowding out Soviet investment, it also tends to crowd out US civilian investment and housing demand. Through international transfers, investments by other market economies are also crowded out.

The world capital markets are linked by interest arbitrage rather than arms competition, which puts the savings of the rest of the world into the pool from which the US can draw. It may be that the exhortations of the US to its allies to increase the share of the defense burden by direct military expenditure is secondary to their participation in the program through the international transmission of capital. (The recent steps toward the internationalization of the Yen under US urging may be apposite here).

The high international value of the US dollar has the effect of crowding out US exports and increasing imports. Insofar as this results from the interest rate, the effect of the arms race is to draw resources into the US from the rest of the world. Of course, individual US firms and unions complain about the loss of markets due to foreign competition, but not all realize that ultimately the cause is the military fiscal stimulation which increases aggregate demand.[5]

The dynamics of rearmament, threat, and hostile action as perceived by the participants, has been the subject of numerous Richardson style dynamic models, including two by the present author some years ago (Wolfson, 1968, 1973). US rearmament may be understood as a response to Soviet actions and intentions as General Bissell contends, as well as the reciprocal Soviet reaction to the US. Consequently, the trajectory of $[M_B, M_A]$ may indeed show a complex path over the plane as Intriligator and Brito suggest. The important fact that can be drawn from previous dynamic models is that they consider plausible combinations of parameters that may lead to indefinite expansion in the arms race as each participant reacts to actions and expressions of the others. Once having achieved a life of its own, the arms race may not be adequately described as a deliberate turn of the screw exerted by strategists, but may escalate through the various levels of economic warfare even if that outcome were no part of anyone's intention.

III.

Let us now study the situation which arises when factor endowments, say, capital and labor, differ between the combatants in economic warfare. We first specify that military power, M, be viewed as a function of the kind of military war being envisaged rather than a simple missile count. Suppose there are high-technology (H) and low-technology (S) instruments of military power. Then we may write for each country:

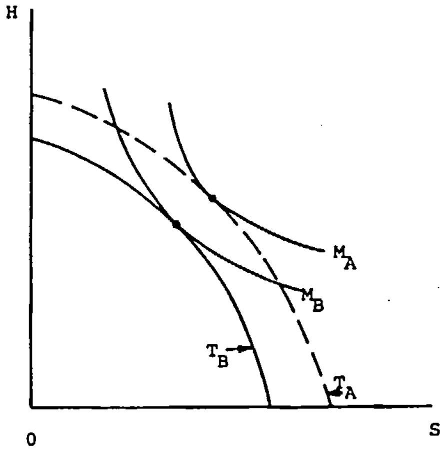
$$M^i = M^i(S, H), \qquad i = A, B$$

For the moment we assume the usual concavity of this function:

$$M^i_S, M^i_H > 0 \text{ and } M^i_{SS}, M^i_{HH} < 0, M_{SS}M_{HH} - M^2_{SH} > 0.$$

Secondly, we may examine the *military* production possibility frontier for these types of warfare $T^i(S, H; GNP - C) = 0, i = A,B$. That is to say, we conceptually fix GNP and subtract the civilian economy C in order to study the transformation trade off between S and H allowed by the resources allotted to the military. We further assume that as the share of the military in the total GNP becomes large, the supply of labour and capital devoted to military purposes must reflect overall national factor endowments. Finally the frontier is assumed to be of the usual sort, concave toward the origin and twice differentiable. (See Figure 3.)

Figure 3
Economic War With Equal
Relative Factor Endowments



Now we are in a position to study particular cases of interest.

Case 1: (Figure 4). Suppose (i) each country has the same relative factor endowment as the other, differing only in size, so that $T^A = \lambda T^B$ where $\lambda = \lambda(\text{GNP}, C)$ is a scale factor; and (ii) there are no military secrets and the military power function of each participant is independent of the choice of S, H made by the others, so that they both work with the same military power function. Then peace occurs only as long as the points on M^A and M^B are sufficiently close, lying within the zone of mutual deterrence when projected onto the vertical axis (not shown). There the stages of hostility depend on whether $(M^A, M^B)\varepsilon\zeta$, if we keep in mind that our analysis of production possibilities in the previous section makes ζ closed and bounded above by the min $T^i(C = 0)$.

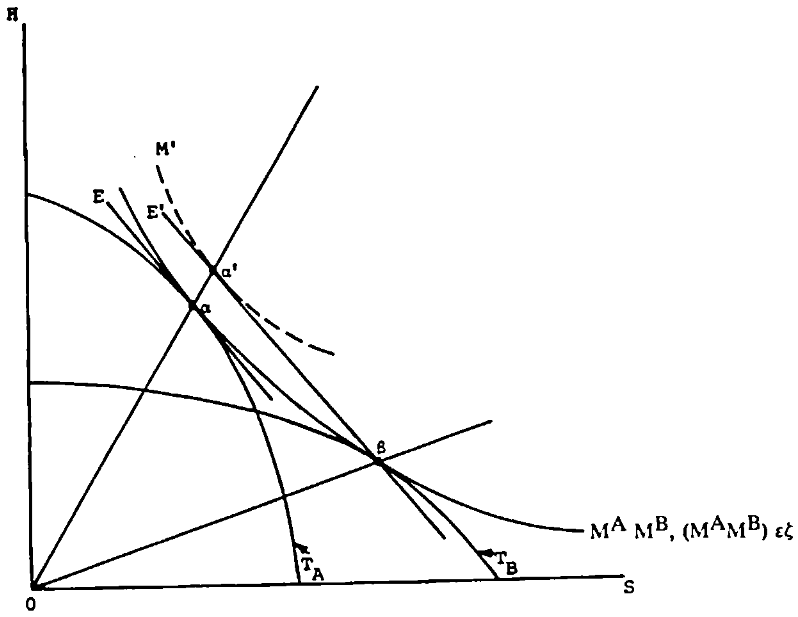
Case 2: Now suppose the nations have very different relative factor endowments. If one country dominates for all kinds of warfare so that $T^i > T^j$ for all S, H, then not much is added to case 1 except that the combinations chosen may be different so that they would prepare for different kinds of war. We can subsume this choice of style of warfare into the more interesting situation where the military production possibility frontiers intersect. We examine two sub-cases: (i) where the military power function is well defined for both parties regardless of the acts of their opponent (Figure 4); and (ii) where the military power function depends on the kind of war the parties expect to be fighting against each other, leading to a lexicographic description of military power (Figure 5). (Alternatively, the military power function may not be quasi-concave, so that the concave regions of their continuous iso-military power contours may be separated by a convex region).

(i) Given the common military power function but different military production possibility frontiers, peace is maintained if both parties move to a common iso-military power contour ($M^A = M^B$) as illustrated in Figure 4, or at least to contours sufficiently close for M^A and M^B to remain within ζ. Each party will, of course, prepare as if it were going to conduct its own preferred kind of military campaign. A will go to α and prepare for "high-technology" war, presumably a capital intensive war measured in physical and human terms; B will choose the opposite form of conflict, mixing its military instruments in the proportion given by the slope of the ray through β.

The problem in maintaining peace is one of perception, for M^A and M^B must not only *be* in ζ, but they must be *seen* to lie in the zone of mutual deterrence. Yet there is the opportunity for the classic index number problem to do serious damage. A must compare M^B with its own capabilities; unless it can map out exactly how a war would eventuate, corresponding to *each point* in the ongoing arms race, it will have recourse to a proxy, which almost always is aggregate arms expenditure. In the absence of a complete Heckscher-Ohlin equilibrium (unlikely between most countries and out of the question between the US and USSR) the decision makers will be pressed to evaluate the arms level of the other in terms of their *own* shadow prices, even when they are aware of the error this induces.

In Figure 4, country A expends E dollars on armaments to reach α at level M^A. If A were to evaluate B's acquisition of β stock of military instruments and personnel as that which A would have to spent in terms of money measured in its own prices, its estimate would be E'. Now, how much military power would E' buy in country A? Clearly M' as country A would go to α' if it were going to spend that much. Hence A always overestimates the level of military expenditures and preparedness of B. Similarly B always overestimates the level of A. The consequent misperception tends to accelerate the arms race as greater and greater budgets are allocated to military programs with the escalation of levels of economic conflict that we have studied previously. (Hearings, 1983, *passim*).

Figure 4
Economic War with Different Factor Endowments

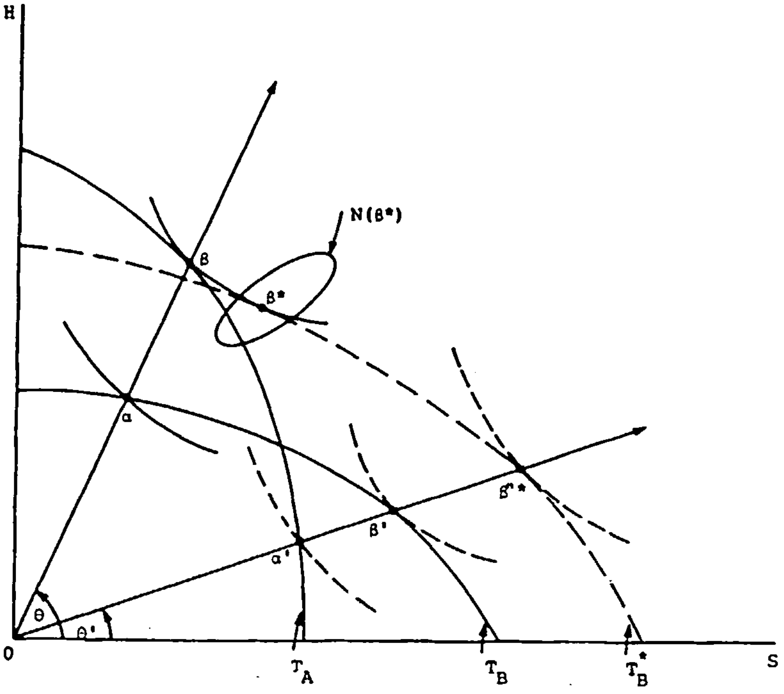


(ii) Consider now the possibility that military power can not adequately be described by a single function over the space of weaponry, but that it has significant lexicographic (or non-quasi-concave) properties. That is to say, it may not be possible to oppose a high-technology attack with low-technology instruments; similarly, it may not be possible to deal with a low-technology war fought by masses of troops by the use of high-technology weapons. The reasons for this may be political as well as military. The Vietnam conflict showed that even if nuclear weaponry might have been effective against the US opponents, this was not a political possibility, and so the US had to fight a relatively low technology infantry action, even though at a much higher level of technology than its antagonists.

The requirement that countries with different factor endowments must nonetheless have to prepare for war contrary to their comparative advantage is illustrated in Figure 5 where the high-technology conflict preferred by A leads it to arm at β with relative combinations of high and low technology given by tan Θ, and country B at β' and Θ' respectively.[6] Now the outcome of the economic war depends on the *type* of conflict that might be fought. If B can be compelled to fight a high-technology war it will have to try to find a point like β^* on the same equal-military-power curve as β, or at least in some neighbourhood of β^* that stays within the cone of deterrence $(\beta, N(\beta^*)) \varepsilon \zeta$.

Figure 5

Economic War with Lexicographic Military Power



That means B will have to greatly increase its allocation of resources to the military sector, moving its military production possibility frontier from T_B to T_B^*. If it did not, and were forced into a Θ conflict, it would only be able to achieve a level of military power through α, increasing the likelihood that $(\alpha, \beta) \notin \zeta$. Lexicographic military power then implies an increased arms expenditure than in the well defined military powers function considered previously.

But the story does not end here. For now B is more likely to dominate A if war were to be fought along Θ'. Indeed this always was possible if $(\alpha', \beta') \notin \zeta$, but now that B is capable of producing military power at a level through β'^*, A is going to expand its military resources allocation (not shown) and so on indefinitely. What will be the outcome of this type of arms race? There are two possibilities. If the two nations' total resources are roughly the same "size", they may *continue to deter one another militarily*, expanding their military budgets to the exhaustion of the civilian sector, since each can threaten a different *kind* of war in which it has the advantage.

If one country's production possibilities exceeds that of the other, the process of whipsawing each other—each preparing for an *expensive* war at which it does not have a comparative advantage—leads to an escalation to the progressively more intense levels of economic warfare that were previously described. The difference is that the directly military considerations impelling the arms race is supplemented by the nature of the economic resource base of each participant. Economic war, like military war, takes on a life of its own and becomes less a matter of restrained measured response and more a conflict that is self-aggravating with a potentially disastrous outcome.

In a world of this last type it would seem that each country would prefer as its opponent one with a *similar* factor endowment (only less well endowed, of course). Ranking the three countries, US, USSR, and China in order of relative capital-labor endowments, we find that the first and the last have incentives to avoid conflicts with each other and to "prefer" conflicts with the USSR. The USSR would seem to have no "preference" for its antagonist. The obvious strategy is for an alliance between the US and China, whose *combined* resource base more nearly resembles that of the USSR, and is presumably much larger. Mr. Gromyko's outburst at the September 1984 meeting of the United Nations seems consistent with this description.

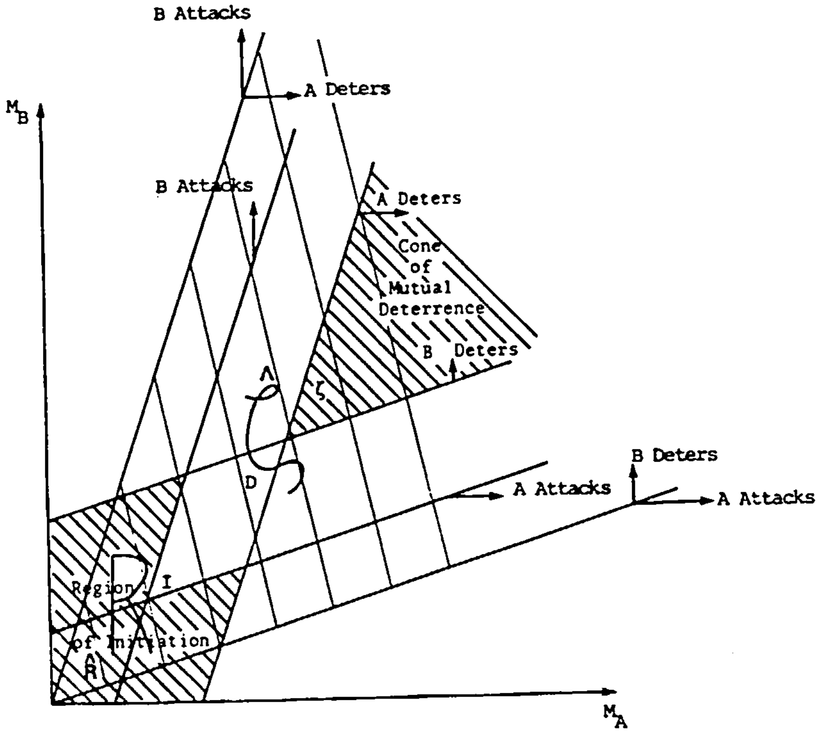
IV.

While Intriligator and Brito have studied the effect of variation in the parameters of missile effectiveness (Intriligator and Brito, 1983) they have not done the same for the behavioral parameters $\hat{C}_i$, $\bar{C}_i$. Historically these parameters vary widely with the political and social climate. The number of casualties in the Vietnam war approximate the traffic fatalities in a like period and were minute compared to the carnage of the two World Wars. Yet in the first instance these were unacceptable, which was not the case in the latter conflicts until their last stages. It may be that popular movements against war may be more effective than deterrence in preventing war. After all, deterrence is founded on the same psychological set that justifies arms expenditures and accepts casualties as justifiable. (The C_i and M_i may not be independent of each other). In so far as a "peace psychology" supplants a war psychology in both parties, the region of war initiation, R, shrinks. In the limit R vanishes when no casualties are acceptable $C_i = C_i = C_i = 0$, ($\xi^i_A, \xi_B \rightarrow 0$ (R = 0)). The ambiguous region between deterrence and attack vanishes so that "A attacks" merges with "B deters", and "B attacks" merges with "A deters," and the zone of the deterrence enlarges to become a cone through the origin (Figure 6).

Figure 6

Reduction in Acceptable Casualties to Zero

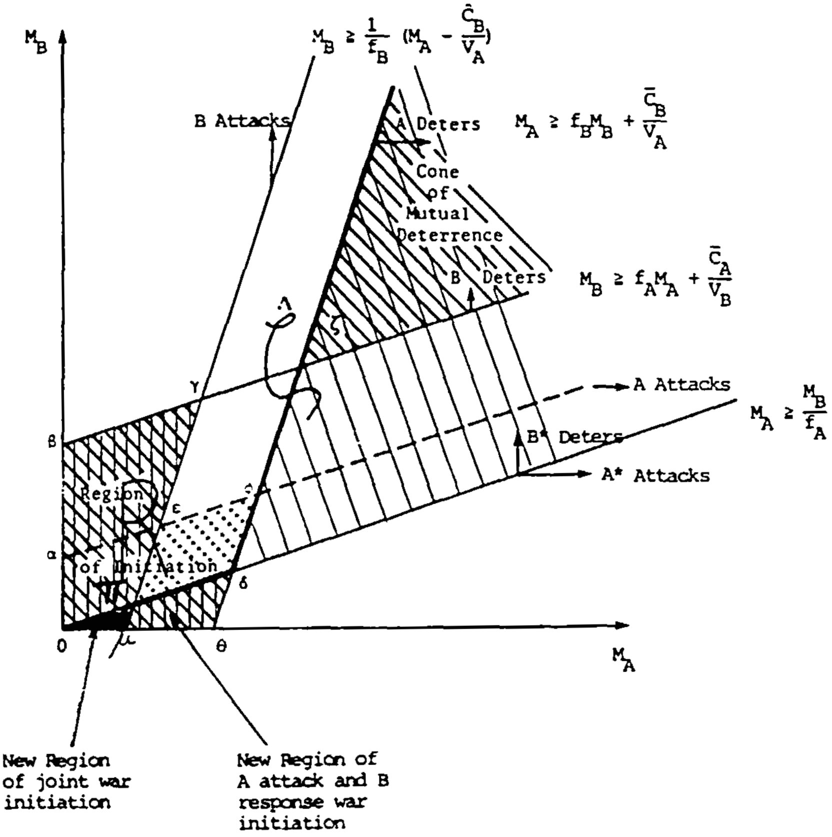
$(\bar{C}_i = \hat{C}_i = 0,\ i = A, B)$: $R = 0$; $\zeta = \hat{\zeta}$ enlarged



While a mutual revulson against war is to be hoped for, and given international transmission of attitudes is not to be excluded, simultaneity is surely too sanguine. We need to study another extreme case in which only one party adopts a policy of finding a zero level of casualties acceptable, say $\hat{C}_A = \bar{C}_A = 0$.[7] In the extreme case where the parties are deterred from attacking by any casualties at all, then Figure 1 becomes Figure 7, where the line "B deters", B*, merges with "A attacks", now at A*.

Figure 7
Asymmetrical Deterring and Initiating
Regions in the Weapons Plane

$(\hat{C}_A = \bar{C} = 0)$



M_B
$M_B \geq \frac{1}{f_B}(M_A - \frac{\hat{C}_B}{V_A})$
B Attacks
A Deters
$M_A \geq f_B M_B + \frac{\bar{C}_B}{V_A}$
Cone of Mutual Deterrence
B Deters
$M_B \geq f_A M_A + \frac{\bar{C}_A}{V_B}$
λ
ζ
Y
β
Region of Initiation
ε
α
δ
A Attacks
$M_A \geq \frac{M_B}{f_A}$
B* Deters
A* Attacks
0
μ
θ
M_A
New Region of joint war initiation
New Region of A attack and B response war initiation

As a result, the cone of mutual deterrence bounded by "A deters" and "B deters" (vertically lined) is enlarged by the unwillingness to accept casualties as an attacker. Furthermore, that portion of the ambiguous region between B deters and A attacks has been reduced.

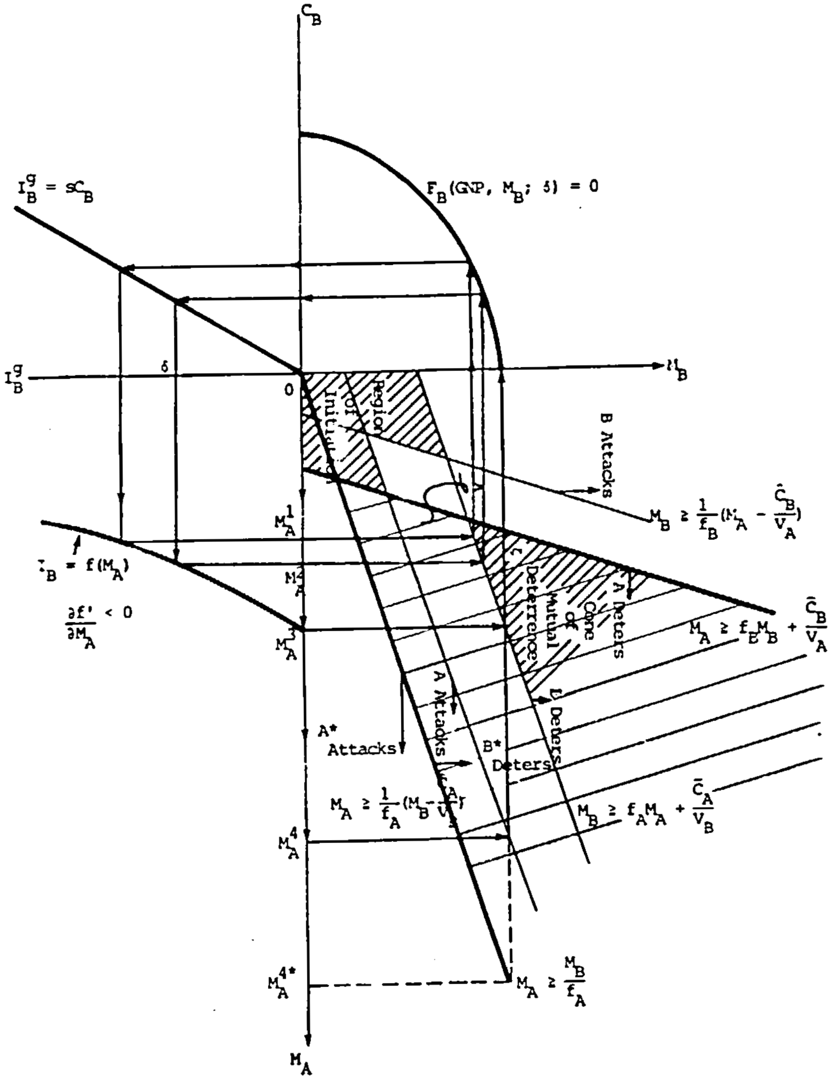
The region of war initiation is also reduced. The region ($\alpha\varepsilon\gamma\beta$) where only B attacks and yet B cannot deter A from striking back has vanished from R, since A will not accept casualties and is therefore deterred. The region of joint war initiation $\hat{R} = 0\mu\varepsilon\alpha$ is now reduced, since B deters A at B*, and hence only at $0\mu\pi$ will they attack each other. The remainder of the region R, $0\pi\varepsilon\alpha$, merges with the previous mentioned area where B attacks but A does not retaliate. The area $\pi\delta\phi\varepsilon$, which used to be part of the war initiation set R, now becomes uncertain since B* deters A, but B does not yet attack, since the level of casualties is too high to be acceptable. The region $\mu\Theta\delta\pi$ is a region where A* attacks, but a cannot deter A. So the region of war initiation is reduced to the joint attack area $0\mu\pi$ and the A* attack and B response $\mu 0\delta\pi$.

Of course regions where one party attacks and the other is deterred from responding may avoid continued war, but they are regions of political domination that can be unacceptable. This was true of all such areas even when $C_A > 0$, but now such regions are enlarged by A's unilateral unwillingness to endure losses ("Better red than dead") to include the area above 0π and the rest of the B attacks line.

Now we look at the consequences of unilateral refusal to accept casualties for economic warfare. Figure 8 superimposes Figure 7 on Figure 2. A has not quite given up waging economic warfare on B, since B must still generate sufficient M_B to deter A. Nevertheless, their task is much easier and requires fewer resources drawn from the civilian economy. The levels of hostility culminating in an attack by A increasingly strain its economy: for instance A would have to devote $M_A^{\cdot}$ to the military before it attacks B.

It is interesting to note that even if A effectively abandons efforts to wage economic warfare against B, it does not at all follow that now B is more successfully able to wage economic warfare against A. This is so because the lines "B attacks" and "A deters" are not affected by the shift to $\bar{C}_A = \hat{C}_A = 0$. A is able to deter B as effectively as before with the same resource allocation. The loss to A is its much attenuated ability to put pressure on B to modify its behavior for purposes not examined in this model.

Figure 8
Levels of Economic Warfare



C_B
$I_B^g = sC_B$
$F_B(GNP, M_B; \delta) = 0$
I_B^g
δ
0
M_B
Region of Initiative
B Attacks
$M_B \geq \frac{1}{f_B}(M_A - \frac{\bar{C}_B}{V_A})$
M_A^1
M_A^2
M_A^3
$I_B = f(M_A)$
$\frac{\partial f'}{\partial M_A} < 0$
Cone of Mutual Deterrence
A Deters
$M_A \geq f_B M_B + \frac{\bar{C}_B}{V_A}$
A Attacks
B Deters
A* Attacks
B* Deters
$M_A \geq \frac{1}{f_A}(M_B - \frac{\bar{C}_A}{V_A})$
$M_B \geq f_A M_A + \frac{\bar{C}_A}{V_B}$
M_A^4
M_A^{4*}
$M_A \geq \frac{M_B}{f_A}$
M_A

V. Conclusions

We conclude from this exercise that the arms race is not to be understood as a somewhat expensive form of international gesticulation which of itself does not constitute an act of hostility. Rather, as the aggregate level of expenditure grows, it takes on the form of economic warfare, more or less consciously directed against the economic and military capability of opponents.

As the war proceeds it tends to feed itself as differently endowed countries systematically overestimate the level of their opponents' activity and strive to deter them. In the case of qualitatively different kinds of war and different factor endowments, the whipsawing effect of increased military expenditures is even greater. It gives rise to systems of alliances in which the possibility of enlarged and "successful" economic war is enhanced.

Economic war merges into military war if it is carried on to an enlarged scale, either as a result of preventive first strikes by an outclassed participant, or the assertion of ascendency by the dominant military power.

Economic war, like military war, is to be understood as political conflict carried on by other means. If economic war is to be waged, then it must be done with restraint and strictly limited goals understood by all parties. The tendency for this type of conflict to grow on itself has to be carefully studied. Most of all, the fact of economic warfare inherent in the arms race must be clearly understood to be of the form of war, lest it be carried on beyond deterrence to a point of no return.

• I wish to express my appreciation of help and stimulation to write this paper by Walter Isard (Cornell), Kenneth D. Patterson and R. Charles Vars (Oregon State University), and Michael Burns (Flinders University and University of Adelaide), Kevin Davis and Derek Healey (University of Adelaide). My obligation to Michael Intriligator and Dagobert Brito is obvious. None of these people can be expected to agree with my views, and certainly none is responsible for my errors.

Footnotes

[1] Intriligator first studied nuclear missile warfare as his first essay on deterrence. (Intriligator, 1967). The decision about targeting and rates of missile fire constitutes a variational problem of when to use missiles to destroy the enemy's missiles (thus protecting one's own missiles and populations), and when to shoot to kill people. Intriligator's formulation leads to optimization through Pontryagin's control theory such that the solution is one of "bang-bang" control (no pun intended). Optimal firing rates are either zero or maximum ones, $\alpha = \bar{\alpha}, \beta = \bar{\beta}$, and there is at most one switch between the targeting of the missiles. The actual solution depends on the magnitudes of the structural parameters, and takes the form of time spent in a first strike Θ_A or Θ_B minutes long, and then in a retaliatory strike ψ_A or ψ_B. Thus Intriligator derives values for α, β to use in his differential equation system; he then extends the duration of the process of war over the optimal time intervals.

Intriligator and Brito are then prepared to solve their differential equations for $C_i = C_i(M_A, M_B, \Theta, \psi)$, $i = A, B$. They then posit some minimum level of casualities that would *deter* each party, $\hat{C}_i = \bar{C}_i$; they also posit some maximum *acceptable* level of casualties $C_i = \hat{C}_i$. The difference between C_i and $\bar{C}_i$ results in an ambiguous region. When we substitute these bounds for C_A and C_B, the resulting system of inequalities can be inverted to make M_A and M_B the dependent variables.

[2] Intriligator (1975) refers to Boulding (1962) and himself (1964) who "noted that the upward spiral of missiles is halted at constraint levels, at which each side holds the maximum number of missiles consistent with its resources and institutions." The present author explored models in which the expansion was halted when further hostile action brought the nations to the "brink" of atomic war (Wolfson 1968, 1973).

[3] The generalization of M_B tacitly involves a dimensional change from a *stock* of missiles to a *flow* of military power through the current use of resources. (If one considered only missiles, M_B would be the maintenance, replacement, modernization and operation of the missile stock). Now M_B is dimensionally comparable to C_B as required by the analysis. I am grateful to Mr. Kevin Davis of the University of Adelaide for raising this issue explicitly with me.

[4] Notice that the negation of Intriligator and Brito's "B deters A" is $M_B < f_A M_A + \bar{C}_A / V_B$; this relation differs from "A attacks B," $M_B \leqq f_A M_A + \bar{C}_A / V_B$ in the strength of the inequality and the size of the intercept. Hence $(\bar{C}_A - C_A)$, which represents the difference between the extremes of "unacceptable" casualties and "acceptable" casualties, defines the negotiation room that remains under the "negotiations from strength" situation.

[5] It is interesting to compare the present military buildup under conditions of flexible exchange rates with the early Vietnam expenditure under conditions of fixed exchange rates. In the present case monetary restraint and disinflation characterizes the transfer of resources, while in the previous case inflationary monetary policy caused resources to be transferred to the US as long as the world continued to accept dollars at par under the Breton Woods Agreement.

[6] If the military power function were only non-quasi-concave, the two sets of iso-military power contours would be joined by a convex region, rather than being drawn discontinuously.

[7] I am grateful to Mr. Derek Healey of the University of Adelaide for suggesting this line of inquiry.

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